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APPLICATION
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FOR:	**HIGH EFFICIENCY HYDRAULIC MACHINE WITH RADIAL CYLINDERS**
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HIGH EFFICIENCY HYDRAULIC MACHINE WITH RADIAL CYLINDERS

The invention concerns a high efficiency hydraulic machine with radial cylinders, that is a machine in which said radial cylinders rotate with the drive shaft and through the rolling of a roller associated with the relative piston cross an outer path, or else the path itself rotates, equipped with cams for the generation of alternating motion, in which the composition of the pistons allows a high efficiency to be attained.

The state of the art comprises the hydraulic machines that have been known for years in which in said cylinders the pistons move behind the action of the outer cam and against which they are thrusted by the pressure of the hydraulic liquid present in them. Said type of machine foresees using a roller arranged inside the piston itself between the outer end of each piston and the cam. The rotation of the shaft, or of the liner with the cam, makes said roller slide on the cam realising the radial alternating motion of the piston in the corresponding cylinder. Said rollers are coupled with the corresponding piston with a portion of anti-friction ferrule or with a hydrostatic support bearing: from this comes substantial energy consumption, during the compression of the piston against the path of said cam, indeed by sliding friction between said roller and the piston itself or by leaking of the liquid from said hydraulic bearing. In this last case the hydraulic machine is slightly larger due to the fact that the roller, obviously larger in size, does not enter into the diameter of the liner.

Versions of this type of hydraulic machine have been realised in which each piston is supported by a pin outside of the cylinder in which the piston is inserted; at the side of this pin two rolling bearings are arranged to reduce the friction. These rolling bearings have the outer

ring in contact with said cam, in this case double, i.e. on both sides of the group of cylinders and with the greatest diameter of the cylinder group itself. This embodiment, although realising a good energy yield in contact between pistons and cam, through the contact of said pairs of rolling bearings with the pair of cams, has substantial bulk which prevents it from being used widely and easily.

Such a state of the art is susceptible to substantial improvements with respect to the possibility of realising a hydraulic machine with radial cylinders which, having a high efficiency, also has low bulk.

From the above derives the need to solve the technical problem of overcoming the teaching of the previous embodiments and realising a support with minimum bulk such as to be able to be introduced inside the roller on said outer path, to support the substantial specific pressures generated in the thrust.

A further technical problem is that of minimising the spaces occupied by the inactive parts of the motor and, on the other hand, increasing the spaces occupied by active parts of the motor.

The invention solves the aforementioned technical problem by adopting a hydraulic machine with radial cylinders of the type comprising the pistons with radial stroke, arranged in contact with an outer cam and coplanar with said group of cylinders, each equipped with a roller on the path of said cam, characterised in that it has, in each piston, a rolling bearing arranged with the inner ring coupled or coinciding with the support pin for said roller and the outer ring coupled or coinciding with the roller itself.

Moreover, in a further embodiment, by adopting the roller and the corresponding rolling bearing of a small size such as to allow entry into the liner of the cylinder.

By adopting, in addition, a piston for a hydraulic

machine with radial cylinders with the pistons with radial stroke, arranged in contact with an outer cam and coplanar with said group of cylinders, equipped with a roller on the path of said cam, characterised in that it has said roller coupled in rotation with said piston with a rolling bearing.

Furthermore, in a further embodiment, by adopting, in each piston, an anti-friction ferrule placed in contact with the pin or with an inter-positioned and coupled support element for said roller; said ferrule being coupled with the inner diameter of the roller itself.

Moreover, in a further embodiment, by adopting said element placed between the pin and the anti-friction ferrule consisting of a spacer sleeve mounted with interference on said pin: the anti-friction surface of the ferrule is in sliding contact on the outer surface of said sleeve.

Furthermore, in a further embodiment, by adopting said ferrule in planar iron material wound inside said roller, on which there is a layer of anti-friction plastic material firmly anchored on it through a layer of sintered metal.

Moreover, in a further embodiment, by adopting the thickness of the element in iron material of said bearing between 0.4 and 4% of the sliding diameter; advantageously, the thrust blocks at the sides of said roller resting upon the shoulders of the piston, equipped with at least one face, a layer of anti-friction plastic material and the sintered anchoring layer thereof.

Furthermore, in a further embodiment, by adopting the thickness of said layer of anti-friction plastic material advantageously between 1 and 12 1/100 of a millimetre and the thickness of said sintered metal anchoring layer between 10 and 40 1/100 of a millimetre.

By adopting, in addition, a piston for a hydraulic machine with radial cylinders with the pistons with radial

stroke, arranged in contact with an outer cam and coplanar with said group of cylinders, equipped with a roller on the path of said cam, characterised in that it has said roller coupled in rotation with said piston with an anti-friction ferrule and relative support pin.

Finally, by adopting, in the seals of the hydraulic machines with radial cylinders, both static and dynamic O-rings each consisting of a metal ring mounted with interference in the coupling on the sealing diameter and housed in a throat with slight axial clearance; advantageously, they have a large depth of said throat with respect to its width and the width of the ring and the side shoulder of each O-ring with a width a little greater than the depth of the throat.

An embodiment of the invention is illustrated as an example in the attached six tables of drawings in which Figure 1 is the side schematic view of a hydraulic machine according to the present invention; Figure 2 is the schematic view of a partial radial section of the single radial cylinder; Figure 3 is a schematic view in section III-III of figure 2; Figure 4 is a schematic side view of a piston complete with roller and pin for rotation of a second embodiment of the present invention; Figure 5 is a schematic side section view of the piston of the previous figure; Figure 6 is a schematic side view of the piston of figures 4 and 5; Figure 7 is a schematic axial section view of the piston of figure 4; Figure 8 is a schematic diametric section view of the piston of figure 4; Figure 9 is a schematic axial view of a motor with an outer cam and radial cylinders, equipped with a displacement selector, in which metal O-rings are applied in a further aspect of the present invention; Figure 10 is a schematic axial section view of the piston, like figure 7, but with a different way of lubricating the sliding contact between roller and pin.

Figures 1 shows the drive shaft 1, rigidly connected to

and rotating with the cylinder group 2 in which, in the cylinders shown 3, 4, 5, 6 and 7, there are pistons 8 equipped with a pin 9 on which the outer ring 10 is coupled in rotation through the interposition of small rollers 11, constituting a rolling bearing with rollers. The outer ring 10 is therefore made to roll on the path 12 of the cam 13, arranged in the same axial plane as the cylinder group 2; said ring constitutes the roller of the piston on said path.

Moreover, figure 2 shows the rolling bearing 14 for supporting the drive shaft 1 in rotation on the liner 15 of the hydraulic machine. Said pin 9 is rigidly connected to the body of the piston 8 through caulking 16 of its ends. The small rollers 11 are spaced apart, advantageously, through a single central cage 17, arranged in the middle of them with a seat formed in the outer ring 10 which, as stated, acts as a roller of the piston 8 on said path 12. Said pistons 8 are kept in position by the abutment clip 18 sliding in the axial stubbling 19 on the side of said piston.

Furthermore, figures 4 to 8 show a further embodiment, for obtaining the high efficiency hydraulic machine, comprising a rotating support between the roller 20 and the piston 21 in which the rotation support pin 22, of said roller 20 through the ferrule 23, realised through a planar element 24 in iron material, is wound inside said roller 20, on which there is a layer of anti-friction plastic material firmly anchored on it through a layer of sintered metal; said ferrule being with the inner surface in contact and sliding on the outer surface of a spacer sleeve 25 coupled with said pin 22, with substantial interference. The shoulders 26 of piston 21 support the extremities of said pin 22 with interference, whereas said spacer sleeve 25 realises the axial shouldering of said shoulders 26 during assembly. Moreover, in the axial contact between

said shoulders 26 and the roller 20, the thrust blocks 27 are inserted, consisting of the metal body and coating on one face with said layer of anti-friction plastic material and said sintered anchoring layer. Finally, said figures show the metal O-ring 28 coupled with interference at the diameter of the liner of the cylinder and inserted in a seat 29, in the piston 21, with slight side clearance; the low thickness and the elasticity in elongation allow the assembly of the entire ring 28 in said seat 29.

Figure 9 shows a further embodiment, for obtaining the high efficiency hydraulic machine, in which the sizing of the distributor 30, thanks to the application of the static and/or rotating seals 31 with the metal ring 32, allows the passage sections 33 for the hydraulic liquid to be substantially increased without, moreover, increasing the bulk of the hydraulic machine. This result is obtained since said seals allow the size of the parts adjacent to them, such as the side shoulders 34 of the seats of the metal O-rings 32, to be greatly decreased. Indeed, said figure 9 shows a motor with the selection of the active cylinders for the partial shutting 35 of the displacement, as in the prior art, which however involves the construction of a distributor that is bulkier than usual. By adopting, on the other hand, said static and/or rotating seals 31, consisting of said metal ring mounted with interference on the sealing diameter D and with slight clearance in the seat 36, formed in the coupling hole of said diameter D. The seat 36 is sized with depth of the throat equal to at least 1.5 times the width B of said metal ring 35 in order to allow the assembly of the entire ring inside the hole.

In figure 10, finally, the pin 37 is equipped with a communication hole 38 of the pressurised hydraulic fluid from the crown of the piston 39, which with said hole 38, the duct 40 of the piston and the hole 41 of the sleeve 25

takes said fluid in the sliding surface between said sleeve and the ferrule 23.

The operation of the hydraulic machine according to figures 1-3 has a substantial reduction in friction between the pin 8 and the roller in this case represented by the outer ring 10 of the rolling bearing formed in the end of the piston.

Consequently, the efficiency of the hydraulic machine with radial pistons, of the type described here, has an improvement from the usual 70% to 90% on average near to the static torque. A substantial economic advantage can be obtained by replacing the previous pistons with the roller with sliding friction with the new pistons equipped with the rolling bearing described here. Said hydraulic machine shall thus have a somewhat higher efficiency decreasing the energy wastage to obtain the same work without the need to integrally replace the machine itself.

The pin 9 and the outer ring 10 are treated with setting heat treatments, advantageously carried out on steel of the type with minimised inclusions, to allow a sufficient lifetime of the rolling surfaces.

The performance of the pistons 21 according to figures 4-8, equipped with the rotation support of the roller 20 allows an excellent reduction in sliding friction to be realised with the sliding of the inner surface made from anti-friction plastic material of the ferrule 23 since the thickness of the layer of anti-friction plastic material is minimal, but slightly greater than the maximum size of the particles not held by the filter of the hydraulic circuit where the hydraulic machine is inserted; it also has the thickness of the element in iron material of said bearing between 0.4 and 4% of the sliding diameter on said spacer sleeve 25. In this way, the heat generated in sliding is easily transmitted from the plastic material to the metal parts of the piston without taking said plastic material to

critical conditions. In the same way, the thrust blocks 27, precisely because they are equipped with at least one face with said layer of anti-friction plastic material and said sintered anchoring layer, substantially reduce the friction in the side thrusts which the roller 20 causes on the shoulders 26 of the piston 21 in its alternating radial motion following the cam 13.

Thus, advantageously, the thickness of the inter-positioned thrust blocks 27 in iron material between 10 and 16 1/10 of a millimetre excluding the thickness of the anti-friction plastic material and anchoring sintered layers. Moreover, both in the case of the ferrule and for said thrust block, the thickness of said layer of anti-friction plastic material is advantageously between 1 and 12 1/100 of a millimetre; and the thickness of said layer of anchoring sintered metal is between 10 and 40 1/100 of a millimetre.

Finally, in the new embodiment of the hydraulic machine with the distributor 30 according to figure 9, the shoulders 34 can be reduced to a size slightly greater than the depth of the throat 36. The size of said ring 32 also allows the dimension C of the shoulder 34 to be taken to 2 mm: the width B of the metal O-ring 32 is 1 mm and the depth of the throat 36 is slightly more than 1.5 mm. These seals with a metal ring 32 have given excellent results both if arranged on mutually static surfaces, like indeed between the distributor 30 and its coupling seats, and in the position where the mutual rotation between shaft and seat is strong, like in the coupling between the shaft 1 and its support in the crankcase of the hydraulic machine.

The advantages obtained with the present invention are: the drastic improvement of the losses for friction in the rolling of the roller on the path and on the piston; indeed, the separation of the roller/path and roller/pin sliding surfaces allows the mounting up of the effects of

sliding of the outer surface of the roller on the piston and of rolling on the surface of the cam, typical of the state of the art, to be avoided. Thus, according to the present invention between the outer surface of the roller and the cam there is just rolling friction, whereas between the roller and the support pin there can be sliding friction, with the sliding bearing, or sliding friction, with the aforementioned anti-friction ferrule.

In practical embodiment the materials, the sizes and the embodying details can be different from those indicated, but technically equivalent to them, without for this reason departing from the legal protection of the present invention.